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**RESEARCH TO SUPPORT SCENE SIMULATION AND
TARGET BUILDING CAPABILITIES FOR ACT/EOS**

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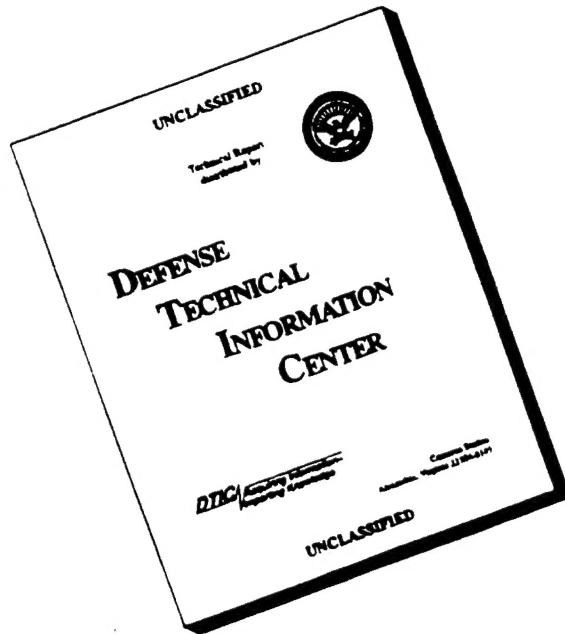
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A software program is described that will enable an analyst to build new variations of a class of models for IR Signature Prediction with the ACT/EOS Thermal Contrast Model, TCM2. This new graphical generic processor program is called xwtherm. The use of this program is detailed in this final report and software manual.			
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Preface

The work was performed by the Applied Research Group of the Keweenaw Research Center of Michigan Technological University under contract F19268-96-K-0001 for the Geophysics Directorate of Phillips Laboratory at Hanscom AFB, MA. The program manager was Keith R. Johnson and the technical lead was Dr. Leonard J. Rodriguez. As of July 1, 1996, the technical team all reside at ThermoAnalytics, Inc. where the final software and report deliverables were completed.

The contract was under the direction of Lt. Col. Joseph Alleca of PL/GPAA.

1. INTRODUCTION

The purpose of the program **xwtherm** is to generate models for input to **TCM2**, an infrared signature prediction program¹. Xwtherm is based on an old application called the generic target processor². Xwtherm adds a graphical user interface with visual cues for the user and graphical confirmation of crucial operations. The approach used by this program and its predecessor is to start with one of several predefined, generic models that define a class of target, such as low head hydroelectric power plants or earth-covered bunkers. The next step is to edit the generic model's dimensions, material properties, and surface properties to more closely approximate the specific target in the selected class that is to be modeled. The available generic model classes were installed with this program, but are not modified by this program. It is recommended that the user run **xwtherm** from a working directory separate from the generic target database. The generic target database should be modified only to install model updates or to edit the "global" material or surface properties lists discussed below.

The balance of this document details use of the program. Its organization mimics the program's user interface.

2. PROGRAM OPERATION

The program runs in an X window environment using OSF Motif, version 1.2 or later, and OpenGL. The program requires a color display that supports the X window pseudo color visual. No unique command line arguments are required. The standard X Window command line options are supported. Two environmental variables, **XWTHERM_PATH** and **XWTHERM_BROWSER** must be set. **XWTHERM_PATH** should be a path name that leads to the generic model database. **XWTHERM_BROWSER**'s value should be the name of a program, such as an internet browser, capable of displaying hypertext markup language, html. Use the full path name of the browser.

The program is composed of several windows. The main window, shown below, is composed of **File**, **Edit**, **Option**, and **Help** buttons; a status line; and a scrollable progress reporting window. The scrollable progress window should be checked periodically for messages on recently completed operations.

¹ Johnson, Curran, Marttila, Yee, Koivunen, Rodriguez, "Phase 2 Development Tasks: Research to Enhance the Phillips Laboratory SIMLAB Capability for Simulating the IR Scene," MTU/KRC, PL-TR-96-2024, Phillips Laboratory, January 1996, ADA307396.

² Rushmeier and Rodriguez, "Generic Models for Rapid Calculation of Target Signatures," Proceedings of the SPIE-the International Society for Optical Engineering, Orlando, FL, April 1991.

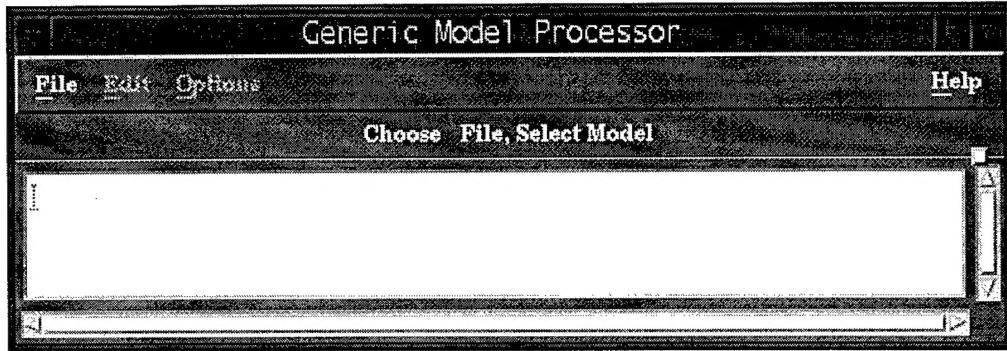


Figure 1. Xwtherm Main Window

2.1 File Menu:

The **File** menu is the normal starting point of **xwtherm**. To start work on a new model, use the left mouse button to select **File** and then **Select Model**. To resume work on a model that was previously edited and saved using **Save** or **Save As**, select **File** and then **Open**.

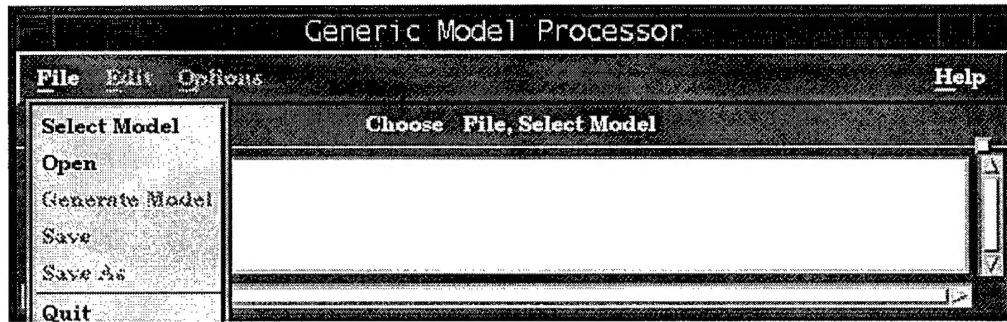


Figure 2. File Menu

2.1.1 (File) **Select Model**:

Pick a generic model from the displayed list and click **Ok**. The program will load the model and display it in the model drawing window shown in Figure 4. The user can select parts, rotate, translate, or zoom the model drawing using mouse buttons and the buttons at the top of this window. Some models require re-scaling immediately after loading and so you may see the model being drawn more than once. The final image is the default model, which can be generated. Typically, you will **Edit** the model before generating the **TCM2** model files.

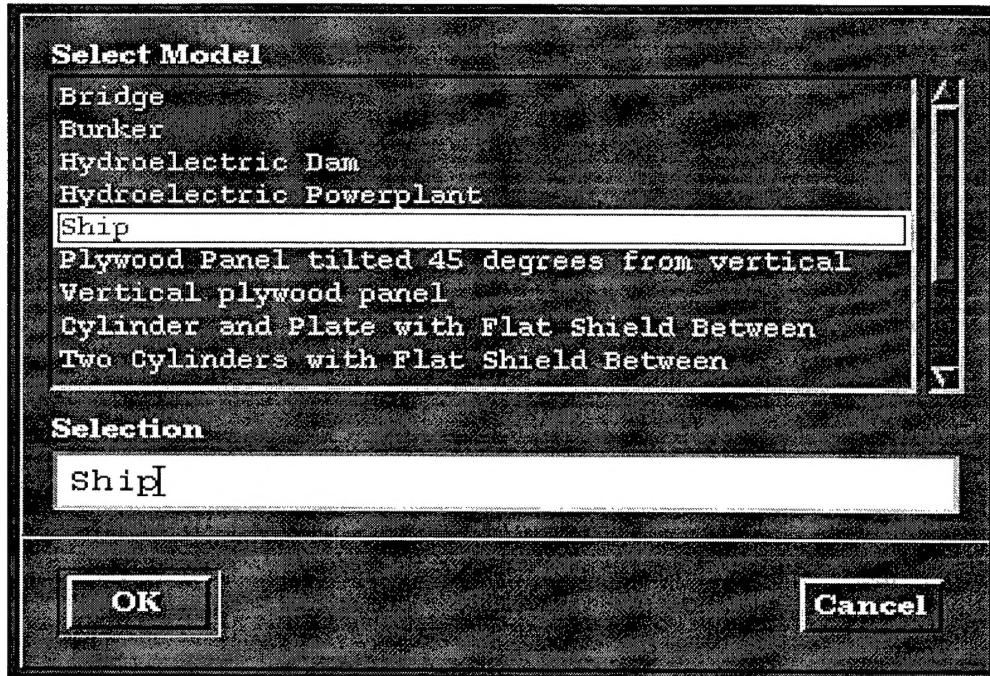


Figure 3. Model Selection List with Ship Selected

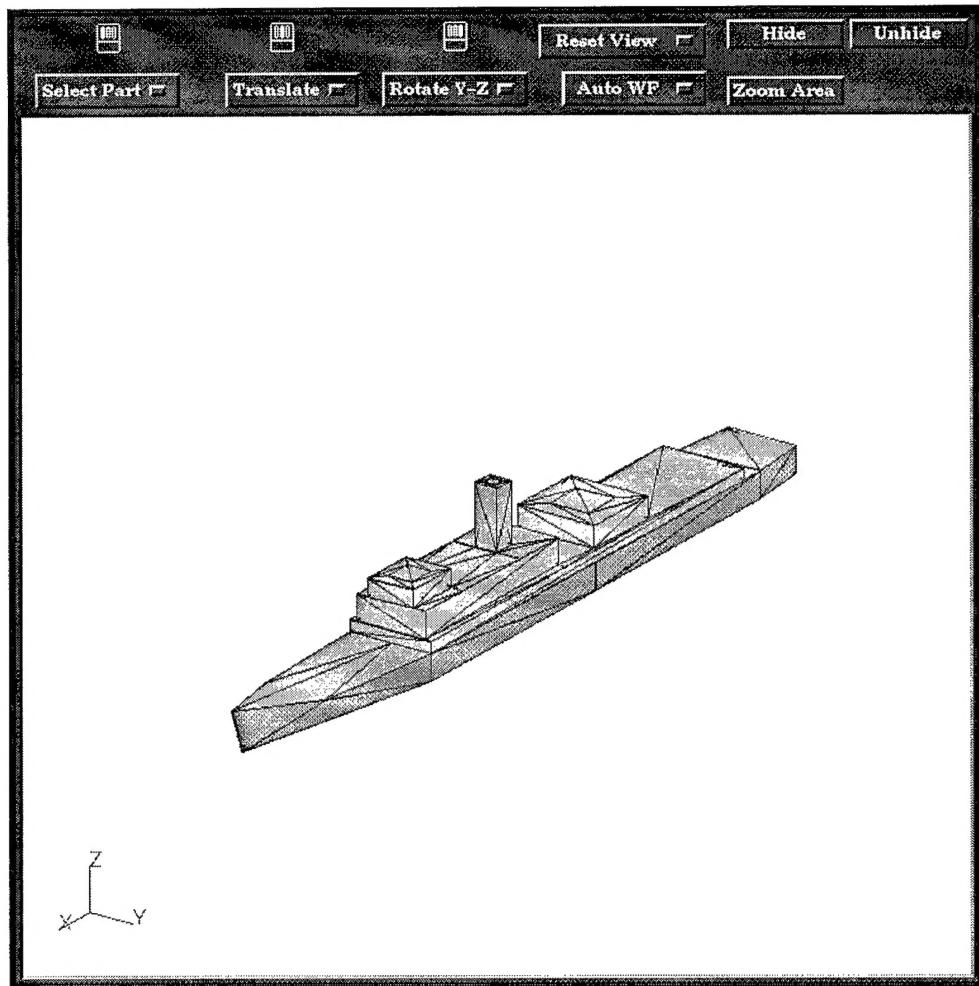


Figure 4. Model Drawing Window Showing Generic Ship

2.1.2 (File) Open:

If you have edited a model and saved it with the **Save** or **Save As** functions, you can **Open** that model and perform further editing and model generation. Normally a model is saved in a file with the file extension of **gnr**, for example **ship.gnr**. Select a **gnr** file from the file list or enter its name and click **Ok**. The program will read the **gnr** file and the generic model from the database. Your saved edits will be re-applied to return the model to the state that the model was in when it was saved. The path and base name of the **gnr** file will become the default file base name. For example, if **../my_models/GoldGate.gnr** is opened, then **../my_models/GoldGate** will become the default file base name for subsequent saves and generates. This function uses the standard Motif file selection window. Note that **gnr** files created by the older program, the generic target processor, are not compatible with this program.

2.1.3 (File) Model Generate:

Selecting this option generates TCM2 model files using the current default file base name and the file extensions .vf, .lwx, .apa, .par, and .fac. If files with names made up of the default base name and the extensions **.vf**, **.lwx**, or **.apa** exist, the program will attempt to re-use the file(s) to save time. The **.par** and **.fac** are not reused. If the **.vf** file (view factors) or the **.apa** file (apparent projected areas) need to be re-computed because of changes to the geometry, a graphical window with a rapidly changing image will pop up. **For the computation to proceed, do not disturb or obscure these image windows.** Examine the scrolling message area in the main window for completion status.

2.1.4 (File) Save:

Saves your current edits in a file with a name made up of the current default base name and the extension **.gnr**.

2.1.5 (File) Save As:

Select or enter a filename to which the current edits will be saved. The suggested file extension is **.gnr**. The filename, less its extension will become the default file base name. This function uses the standard Motif file selection window.

2.1.6 (File) Quit:

Exits the program. You should save and generate models, as needed, before exiting. If the Help browser is open, you should also exit the browser.

2.2 Edit Menu:

The edit menu is composed of two buttons, labeled **Dimensions** and **Properties**. The **Dimensions** option allows adjusting gross dimensions of the model, such as its length and width. The **Properties** option is further subdivided into surface properties and bulk material properties.

2.2.1 (Edit) Dimensions:

The **Edit Dimensions** window provides the means to re-scale several dimensions, such as length and width, of the default model to conform to the specific target being constructed. The adjustable dimensions vary from one generic model to another. The window is composed of 4 columns:

- 1) the current minimum value allowed for the dimension

- 2) the value of the dimension
- 3) the current maximum value allowed for the dimension
- 4) a description of the dimension

Select a value field with the Tab key or mouse. If a “dimension symbol” has been defined for the selected dimension and is active, the model will be redrawn in a view with the dimensioned part centered in the window. A heavy black line, currently the only dimensioning symbol available, will be drawn to locate the model dimension that can be assigned a new value. Figure 6 shows the generic bridge with the “bridge height” dimensioning symbol. The dimension symbols can be turned off, see (**Options**) **Hide Dimension Symbols**. The minimum and maximum values are recalculated when a value field is selected. Enter the desired value. If the value you enter is not in range, it will not be accepted. Enter zero or more values, then select Ok, Apply, Reset, or Cancel.

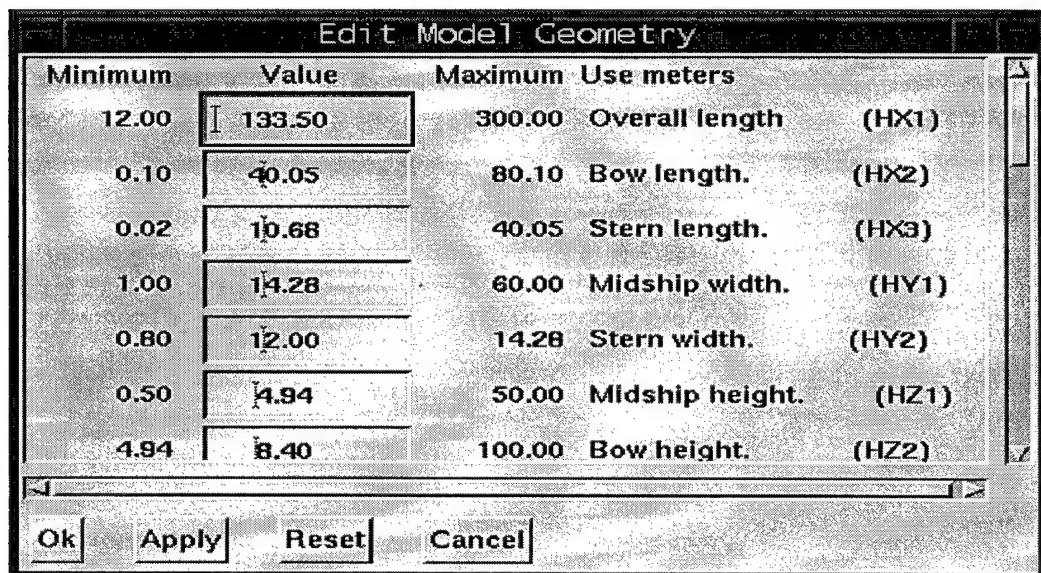


Figure 5. (Edit) Dimensions for the Generic Ship

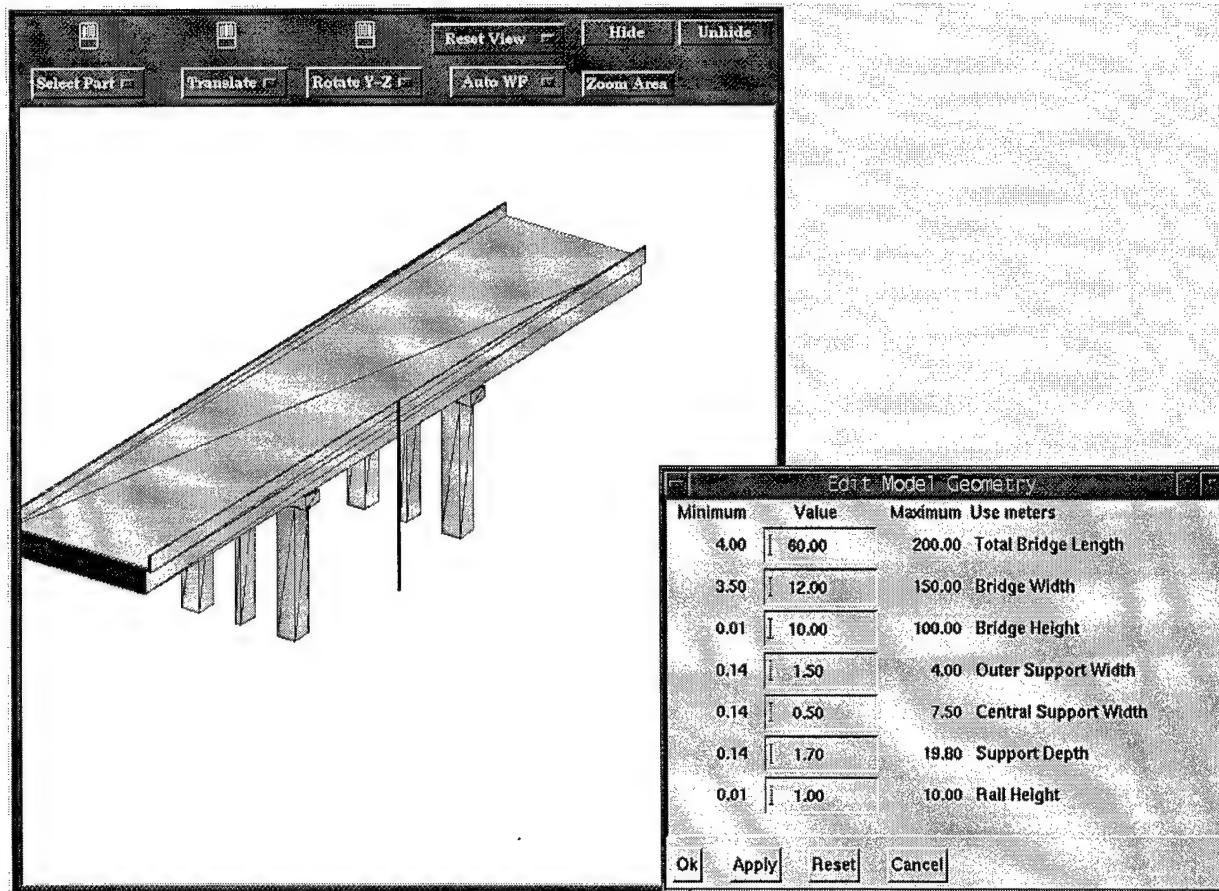


Figure 6. Bridge Height Symbol Overlaying Generic Bridge Drawing

2.2.1.1 (Edit Dimensions) Ok:

When **Ok** is selected, the program computes all the minimums and maximums and checks that all values are in range. There are numerous examples where dimensions are interrelated. For example, the height of some part of an object must be shorter than the object's total height. Therefore, it is possible for a new value for one dimension to invalidate another, related dimension. If any value is invalid, its minimum or maximum will be highlighted with foreground and background colors reversed and none of the changes will be accepted. Correct the out of range values or the values of the related dimensions that are causing the condition. When the values are accepted, the dimension window will close and the model drawing will be re-scaled.

2.2.1.2 (Edit Dimensions) Apply:

Identical to **Ok**, except the dimension window is left open.

2.2.1.3 (Edit Dimensions) Reset:

Resets all values to the last accepted set of values. If the **Ok** or **Apply** buttons have been used successfully, those values would be the last accepted set.

2.2.1.4 (Edit Dimensions) Cancel:

Closes the dimension window, leaving the dimensions with their last accepted set of values.

2.2.2 (Edit) Properties:

Each generic model is composed of several named parts. This window allows the selection of alternate surface and bulk thermal properties. The window is composed of a **Parts** list, **Surfaces** list, **Materials** list, **Ok** button, and **Cancel** button. To select from a list, click on the arrow head immediately to the right of the highlighted list item. After the list drops down, click on the desired line in the list, then click on some point outside the list to complete selection. The selected item should appear as the new highlighted item.

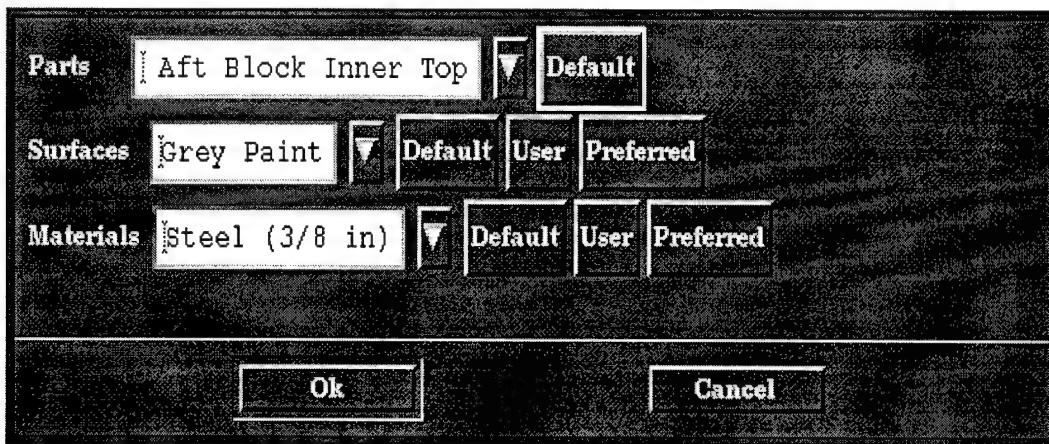


Figure 7. (Edit) Properties for the Generic Ship

2.2.2.1 (Edit Properties) Parts:

Select the model part that is to be edited with the drop down list or by clicking on the part in the model drawing window. The name of the selected part should

appear in as the **Part** item and the part should be highlighted on the model drawing.

2.2.2.1 (Edit Properties) Surfaces:

There are three ways to select the surface condition of the current part: 1) selection from a **Preferred** list, 2) selection from a **Global** list, and 3) direct entry of **User** defined surface properties. The preferred list of surface properties for each part of each generic model is encoded directly in the file that defines that generic model, and presumably includes only properties appropriate for that part of the model. The global list includes a wider selection of surface properties independent of the current part, some of which would not be a suitable choice for that part.

Surface-Default:

This button sets the selected part to the default surface condition for that part only when the **Preferred** list is active. The default button has no specific meaning when the **Global** list is active.

(Edit Properties Surface) User:

Select this option to enter the solar absorptivity and long wavelength (thermal) emissivity of the surface of the part of the model being edited. Both values should be in the range of 0.0 to 1.0. A very low emissivity, for example less than 0.1, may slow the convergence of multi-bounce radiation exchange computation for complex models. This is not a problem for the small to modest sized models in the initial release of this program.

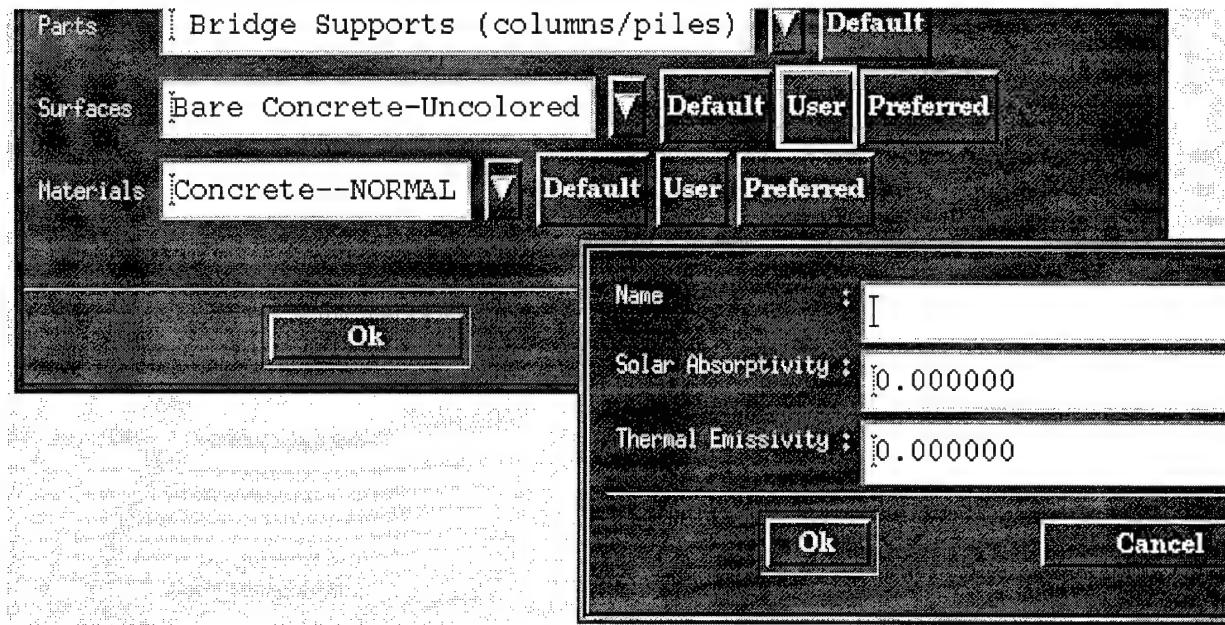


Figure 8. (Edit Properties Surface) User for the Generic Bridge

Surface-Preferred: | Surface-Global:

Alternatively activates the **Preferred** and **Global** lists. There may be an appreciable delay while a **Global** list is being built.

2.2.2.2 (Edit Properties) Materials:

The bulk thermal material property selection is similar to surface property selection. There is some difference in the **User** defined bulk thermal properties that is described below. Note when using the **Global** list or **User** defined material selection with the generic ship model, several of the preferred material properties have been scaled to permit selecting from a list of different material thicknesses.

(Edit Properties Materials) User:

Select this option to enter thermal property values for the part of the model being edited. Enter the thermal conductivity in Watts per meter per degree Kelvin, heat capacity in Joules per kilogram per degree Kelvin, and mass density in kilograms per cubic meter. The program will display the heat capacitance per unit volume (Joules per degree Kelvin per cubic meter). This value will be used to compute the heat capacitance of the current model part when a model is generated. The user should take care to use correct values for realistic materials for the current application.

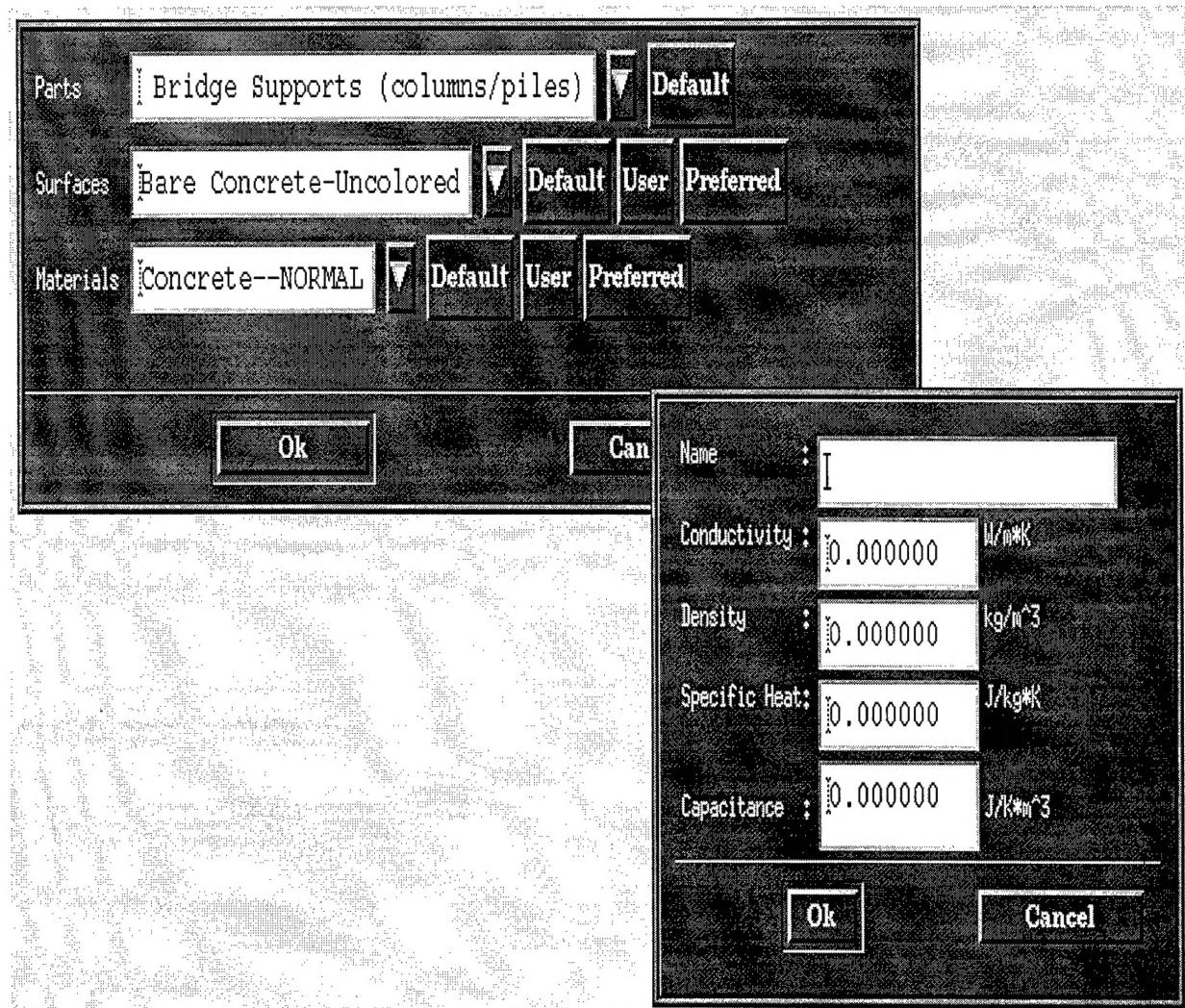


Figure 9. (Edit Properties Materials) User for the Generic Bridge

2.3 Options Menu:

The **Options** menu includes miscellaneous items that the user may select or deselect at their preference.

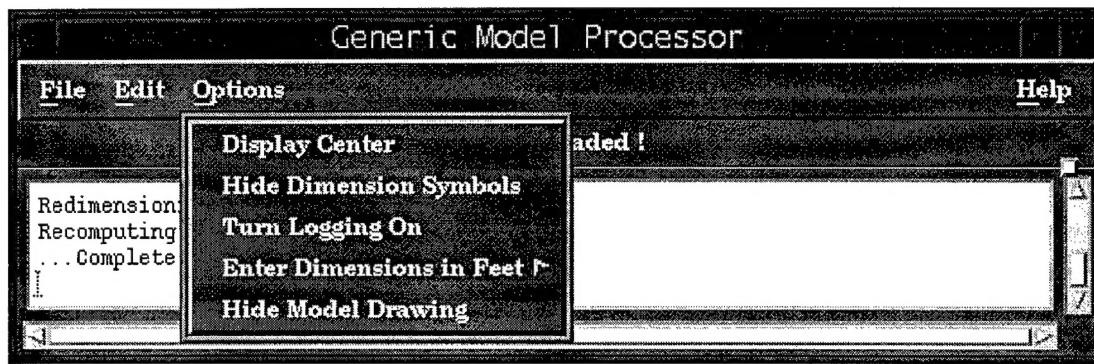


Figure 10. Options Menu

2.3.1 (Options) Display Origin:

This option draws a large axis with x, y, and z labels at the origin of the model's coordinate system (0, 0, 0). This may assist the user that intends to use scene rendering software to insert the model into a scene with the correct model orientation and positioning. The axes will disappear as soon as the model is redrawn.

2.3.2 (Options) Hide Dimension Symbols: / Show Dimension Symbols:

This option toggles off/on the display of "dimensioning symbols" during the use of **Edit Dimensions**. If the symbols are being displayed, after the user selects a particular dimension to edit, such as bridge height, the program will switch to a preferred view for that dimension and superimpose a heavy dark line on the model display to convey which dimension is being edited. The default is to display dimensioning symbols.

2.3.2 (Options) Turn Logging On: / Turn Logging Off:

This option toggles off/on the writing of status, warning, and error messages to a text log file with the name <model>.log where <model> is the name of the current model. The default is logging Off.

2.3.3 (Options) Enter Dimensions In Feet: / Enter Dimensions In Meters:

The user can elect to use meters or feet for specifying model dimensions. The default is meters.

2.3.4 (Options) Hide Model Drawing: / Show Model Drawing:

The model drawing can be hidden or shown. The default is to show the drawing. As an alternative, pressing the Escape key when the drawing window has input focus, will hide the drawing. Opening or selecting a model will pop up the model drawing. Use the Escape key or this option to pop it down, if desired.

2.4 Help

Help is available for each of the major **xwtherm** windows, with the exception of the drawing window. The help is contained in the file `$XWTHERM_PATH/help.html`, where `$XWTHERM_PATH` is the directory path of the generic model database. This file is in the hypertext markup language. Pick a program capable of displaying html documents, such as an internet browser. Assign the browser's executable name, including path, to the environmental variable `XWTHERM_BROWSER`. You can activate help by selecting the Help button on the Main Window menu, illustrated below, or by pressing function key F1 while the focus is on any **xwtherm** window except for the model drawing window. Help has not been implemented for the drawing window. Note that the help browser runs independent of the main program and should be exited independently. Also, since the help information is contained in a single file, there is little reason to invoking multiple simultaneous copies of the browser.

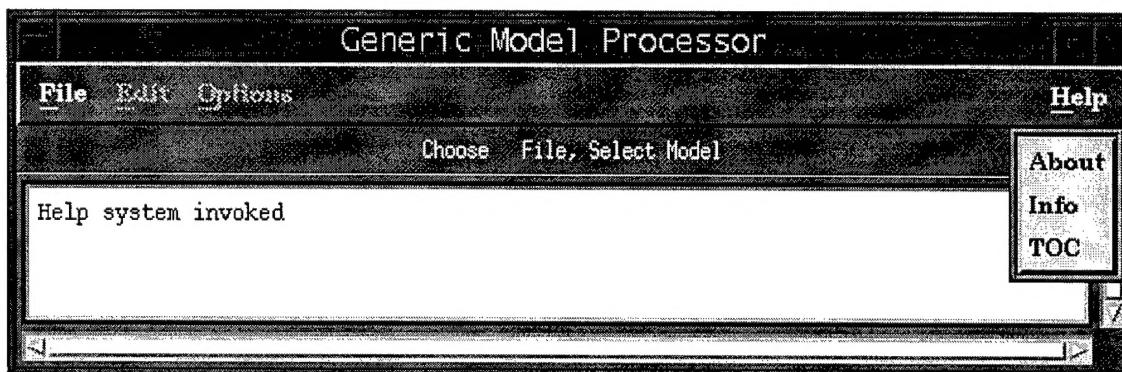


Figure 11. Help Menu

2.4.1 (Help) About:

Pops up a brief description of the program.

2.4.2 (Help) Info:

Click on this option and then on an **xwtherm** window to initiate the browser on the section of the help document relevant to the selected window.

2.4.3 (Help) T O C:

This selection initiates the browser on the Table of Contents of the help document.

3. DISCUSSION

This program will provide the capabilities to modify generic target models very easily through the use of graphical components built into the user interface. The state-of-the-art view factor module within **xwtherm** will provide updates to geometry with extreme speed and accuracy.

Once the user has selected the menu inputs for model modifications, a infrared prediction can be made with the signature code **TCM2**. The output products of **TCM2** are used in the Phillips Lab **Scene Builder**.

A new tool will also be developed by ThermoAnalytics for Phillips Lab that will allow a user to construct new Target Classes through the **Generic Target Builder** from simple CAD geometry. This tool is scheduled to be completed by June 1997.